

Development of a cognitive task to probe conceptual prevalence in thermodynamics in undergraduates

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Abstract

Entropy and the second law of thermodynamics are challenging concepts for first-year undergraduates as they sometimes are subjected to alternative conceptions. We developed a congruent-incongruent true-false task to evaluate the prevalence and possible coexistence of some known alternative conceptions by measuring accuracies, response times (RTs) and feelings of confidence. N=115 first-year undergraduates in a Belgian university undertook two tasks in a pre-test/post-test design in the context of a general thermodynamics course: our home-made task, and another, adapted from Shtulman and Valcarcel (2012). Results from the latter show good accordance with the authors' own results, while results from the entropy task show lower accuracies, lower confidence and higher RT for inconsistent statements compared to consistent statements. Pre-post comparison reveals rather disparate changes in measurements, which might be indicative of inconsistent prevalence, and the limited teaching impact of the usual thermodynamics course on prevalence shifts.

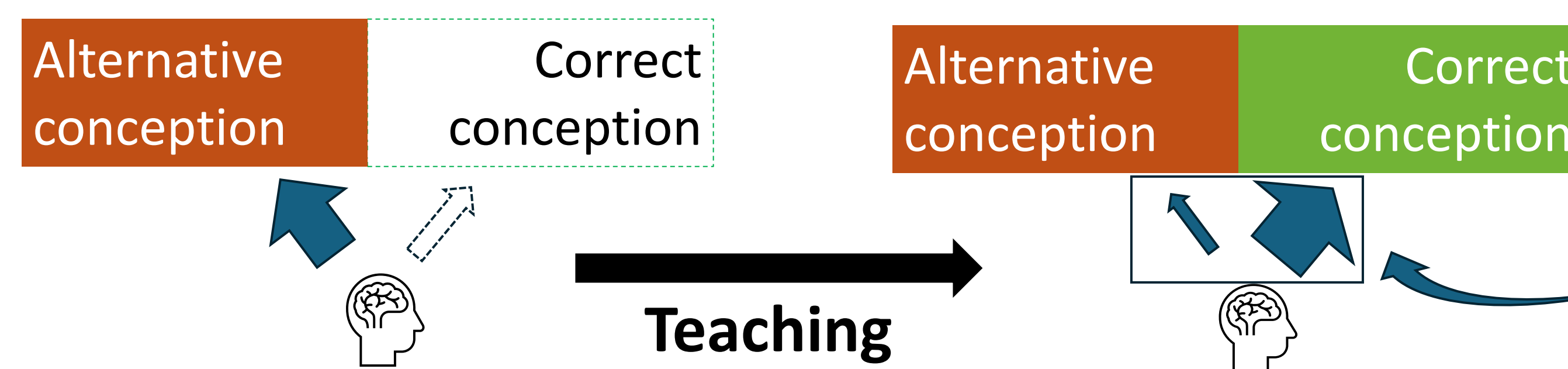
Context

Coexistence hypothesis

Among experts

- Science education → questionnaires
- Neurosciences → fMRI
- Psychology → response time
- Epistemology → pluralism

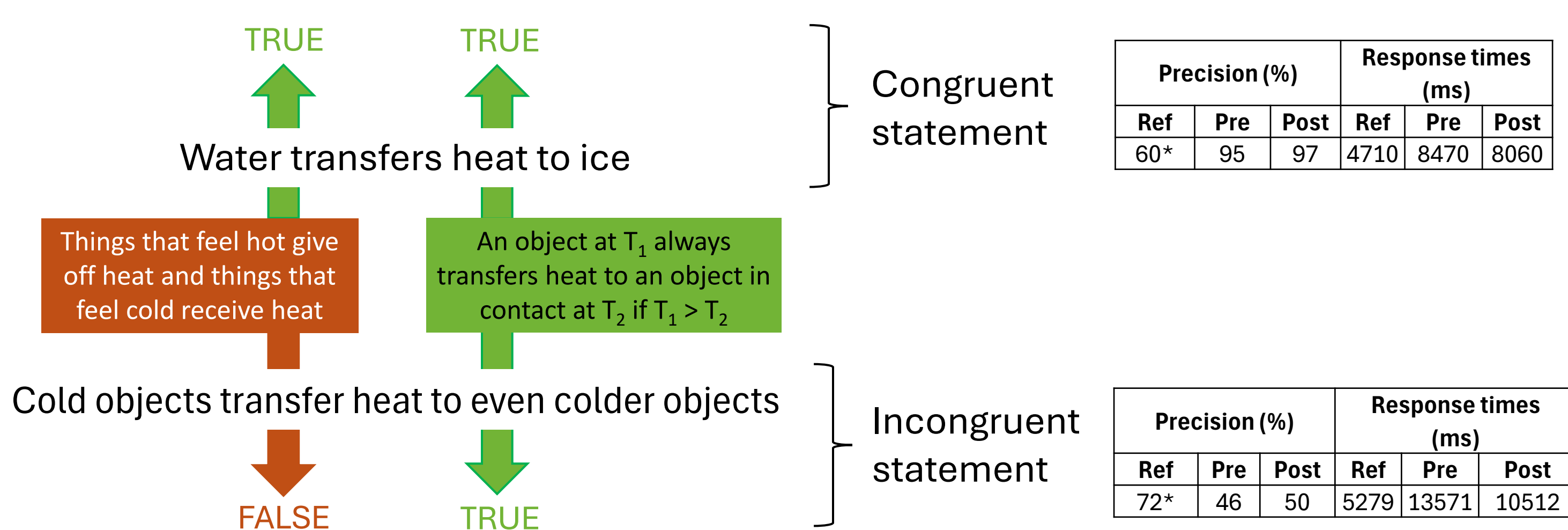
Conceptual prevalence



Objective

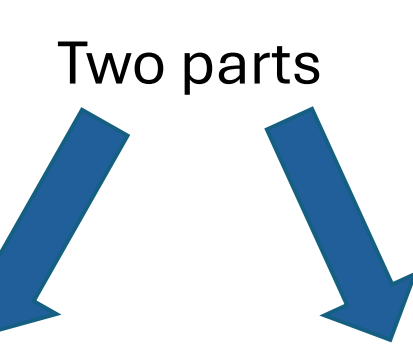
Measure the prevalence of multiple alternative conceptions in thermodynamics before and after a course

Method



N = 115 first-year undergraduates

Pre-test and a post-test at the beginning and end of an introductory thermodynamics course



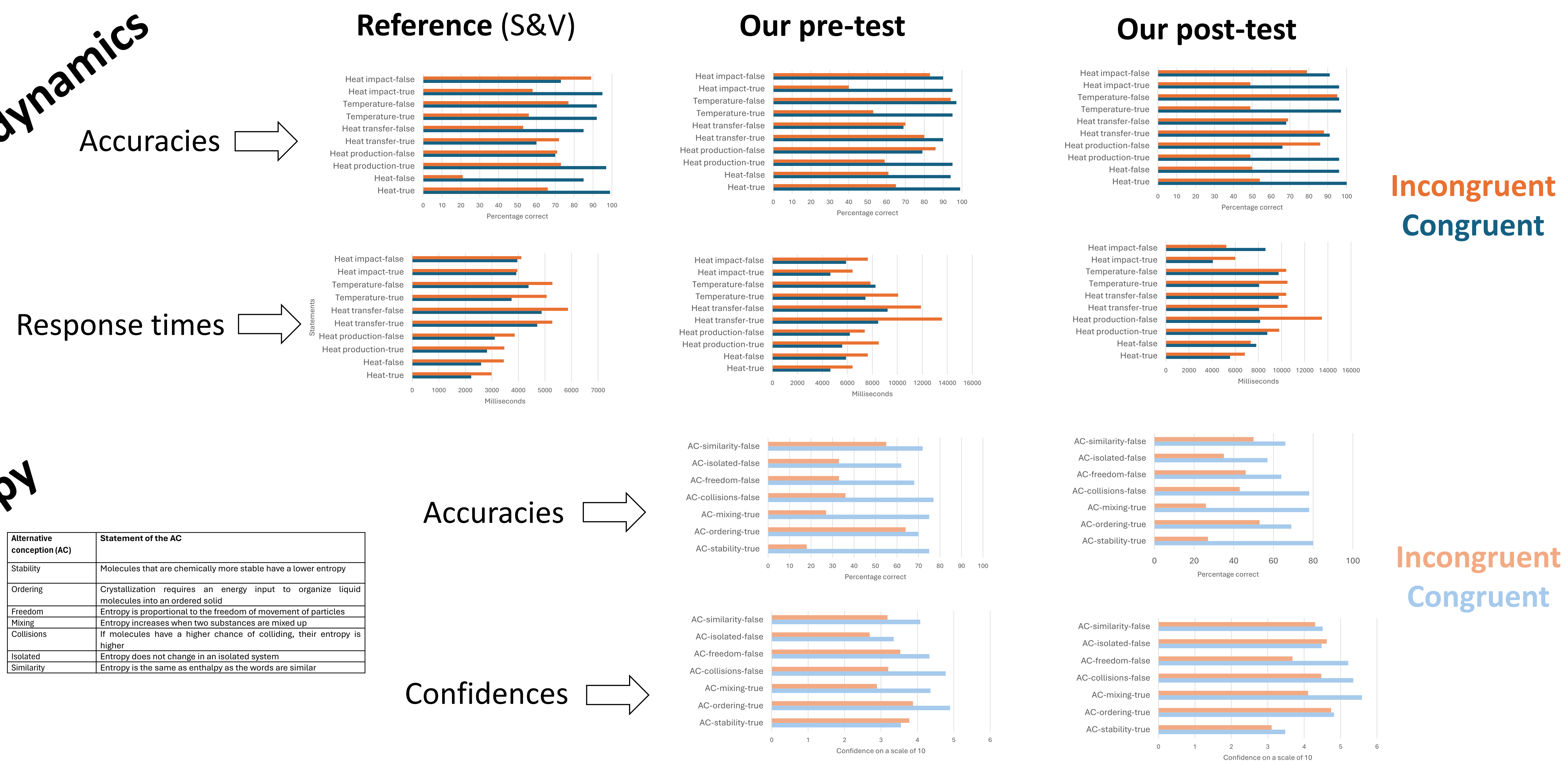
Thermodynamics Entropy

Hypotheses
 $Precision_{congruent} > Precision_{incongruent}$
 $Confidence_{congruent} > Confidence_{incongruent}$
 $Response\ time_{congruent} < Response\ time_{incongruent}$
 → Prevalence of the alternative conception

Results

Thermodynamics

Entropy



Conclusion & perspectives

1. Confirmed method hypotheses for precision and confidence
2. But not RT: methodological improvement needed + language effects to take into consideration ?
3. Partial improvement from the course, showing the difficulty of improving conceptual prevalence when not targeted explicitly
4. Extension to all known alternative conceptions undergraduate level → data in late 2024

Take home message

Picking a correct answer to a true-false question is the result of competing conceptions/explanations in one's mind. The prevalence of alternative conceptions over correct conceptions can be measured by three indicators (precision, response time and confidence). In an undergraduate thermodynamics course, prevalence of multiple alternative conceptions is high and is only partly (and probably temporarily) changed by the thermodynamics course.